A HULL
FOR AN AMPHIBIOUS VEHICLE

The present invention relates to a hull and, in particular, to a hull for an amphibious vehicle.

The designers of planing hulls for watercraft usually adopt a deadrise angle of between 14 and 18 degrees amidships. The angle may flatten along the run aft to 2.5 to 4 degrees at the transom. The applicant has determined that for an amphibious vehicle with a planing hull it is desirable to have a maximum deadrise angle of about 6 degrees on the planing surface in order to provide for adequate ground clearance when the vehicle is used on a road. Such a low deadrise angle detrimentally affects directional stability of a hull when planing on water. In order to address this problem, the applicant provides a pair of strakes running lengthwise along the underside of the hull in order to improve directional stability of the hull when planing on water.

Normally it is only slow speed displacement vessels that use a smooth hull without hydrodynamic aids. Traditionally, a keel is a protrusion from the smooth under surface of a hull along its longitudinal centre line. This definition dates back to the days of wooden ships, when the keel was the first part of the ship to be laid down during its build.

More recently, the term keel has been applied to one, or a pair of, deep fin(s) which extend downwards from a hull on, or on either side of, its longitudinal centre line. Such fins are also known as skegs, and are particularly popular on sail driven vehicles, from windsurfers to yachts; where their depth can provide great stability against lateral wind forces.

Strakes are relatively shallow structures, of similar depth to a central, full length, keel; but laterally displaced to either side of a vessel's longitudinal centre line.

Skegs are readily distinguished from strakes, in that:

a) skegs are only about one quarter the length of the hull, whereas strakes extend along substantially the full hull length;

b) skegs are themselves of greater depth to the rest of the hull structure - considerably deeper in the case of a windsurfer - whereas a strake would typically be less than 10% as deep as the rest of the hull;

c) skegs are rarely, if ever, fitted to amphibious vehicles; because they would nullify ground clearance, and because amphibians are not generally wind powered.

Amphibious vehicles operating in displacement mode are limited to a speed of around six knots. At such speeds, which hold little marketing appeal, hydrodynamic aids have little effect; and the vessel remains substantially level when turning. A planing amphibious vehicle, however, may travel on water at 15 knots or more, and will lean into corners; so strakes can be useful hydrodynamic aids.

Keels and strakes are particularly useful for vessels driven by water jets, which have no dependent structures below the general level of the hull. By contrast, the drive pod, propeller, and rudder of an outboard motor can act as lateral stabilizers.

The present invention provides in a first aspect a hull for an amphibious vehicle with an underside submersible in water and at least one strake extending lengthwise along at least part of the underside, wherein the strake at least in part has a pair of surfaces which both extend downwardly from the hull at an angle of 75 degrees to 90 degrees to horizontal when the hull is level, each of the surfaces when immersed in water capable of giving rise to a lateral force on the hull during turning of the hull in water.

The present invention provides in a second aspect a hull for an amphibious vehicle with an underside submersible in water and at least a first pair of strakes extending parallel to each other lengthwise along at least part of the underside, wherein each strake at least in part has a pair of surfaces which both

extend downwardly from the hull at an angle of 75 degrees to 90 degrees to the horizontal when the hull is level, each of the surfaces when immersed in water capable of giving rise to a lateral force on the hull during turning of the hull in water. The two strakes of said pair are preferably located one each on either side of a keel provided centrally on the underside of the hull, the strakes being spaced equidistantly from the keel.

The strakes of the prior art have been provided in parallel extending pairs on the underside of a hull, but have been triangular in cross-section so that each strake has one side inclined to provide a significant resistive transverse force during turning, but with the other side inclined to provide little resistive transverse force during turning. In the present invention both sides of each strake are used to provide a significant resistive transverse force.

Preferably the or each strake has a forward part which is substantially triangular in transverse cross-section and a rearward section which is substantially quadrilateral in transverse cross-section. The or each section has a pair of surfaces each capable of giving rise to a lateral force, but said forces are greater, and more evenly balanced, at the rearward section.

It is preferable to have only at the rear of the hull a strake with a pair of sides capable of giving rise to greater resistive transverse forces, because otherwise the hull will be difficult to turn in water when not planing. It is only the rear of the underside of the hull which remains immersed in water when the hull is planing.

Preferably the or each strake extends along the majority but not the complete length of the underside of the hull. Preferably the or each strake does not extend lower than the lowest part of a keel of the hull. Where the hull has removable panels then the or each strake can extend over the panels.

The or each strake can have a section formed integrally

with the hull and a section formed independently of the hull and then fixed to the hull. The said independently formed sections can be forward or rearward removable sections, so as to ease replacement when damaged. An independently formed section can extend over a removable panel in the underside of the hull and can be removable to allow removal of the removable panel.

A preferred embodiment of hull according to the present invention will now be described by way of example only with reference to the accompanying drawings, in which:

Figure 1 is a plan view of an underside of a hull according to the present invention;

Figure 2 is a perspective view from below of the hull of Figure 1

Figure 3 is a cross-section through the hull of Figure 1 taken along the line x-x';

Figure 4 is a cross-section through the hull of Figure 1 taken along the line y-y';

Figure 5 is a detail view of the cross-section of Figure 3; and

Figure 6 is a detail view of the cross-section of Figure 4.

In Figures 1 and 2 there can be seen a hull 11 of an amphibious vehicle 10 having a forward bow end 12 and rear stern end 13. The underside of the hull 11 is shown and provided on the underside are a pair of strakes 14, 15 spaced equidistantly from a keel 16. Each strake 14, 15 runs lengthwise along the underside of the hull 11 for the majority of, but not the whole length of, the hull 11. The underside of the hull 11 is provided with removable panels 7, 8, 17, 18 which are hydrodynamic aids (planing plates) as described in the applicant's co-pending UK patent application no. 0311499.8 entitled 'A Hull For An Amphibious Vehicle'. One section of each strake 14, 15 is formed integrally with the hull 11 and another section formed integrally with, or assembled to, one of the removable panels 17, 18.

The forward sections of the strakes 14, 15 are triangular

in cross-section, as can be seen in Figure 3, and in detail for strake 14 in Figure 5, Figure 5 being an enlarged view of part of the cross-section of Figure 3, showing strake 14 in detail. Looking at Figure 5, it can be seen that the strake 14 has a face 19 which extends at an angle α of approximately 50 degrees to the horizontal when the hull is level and a face 20 which extends at an angle β of approximately 15 degrees to the horizontal when the hull is level. When the strake 14 moves through the water in the direction of arrow 21 at a first speed then interaction of the face 19 with the water gives rise to a transverse force of a first magnitude on the hull resisting the motion. When the strake 14 moves through the water in the direction of the arrow 22 at the same first speed then interaction of the face 20 with surrounding water gives rise to a transverse force of a second magnitude smaller than the first magnitude, due to the fact that the faces 19 and 20 lie at different angles to the horizontal.

The strake 15 is a mirror image of the strake 14. It too has faces inclined at different angles. Strakes 14 and 15 are shown with rounded corners between faces 19 and 20. This aids demoulding, particularly in series production. If it is desired that any part of strakes 14 and 15 which is not immersed in water should act as a spray rail, it may be moulded with a sharp corner between the inclined faces.

The rearward sections of the strakes 14, 15 are quadrilateral in cross section, as can be seen in Figure 4 and in detail for strake 15 in Figure 6, Figure 6 being an enlarged view of part of the cross-section of Figure 4, showing strake 15 in detail. Looking at Figure 6 it can be seen that the strake has a face 23 which extends at an angle γ of approximately 82 degrees to the horizontal when the hull is level and a face 24 which extends at an angle θ of approximately 85 degrees to the horizontal when the hull is level. Alternatively, angles γ, θ may be substantially equal, say 85 degrees. Indeed, angles γ, θ could be any angle from 75 to 90 degrees. The interaction of the face 23 with water gives rise to a significant resistive lateral force when the strake moves in the direction of the arrow 25 and

the interaction of the face 24 with water gives rise to a significant resistive lateral force when the strake moves in the direction of the arrow 26. Strake 14 is of the same cross-section as strake 15, but in mirror image thereto.

The quadrilateral shaped sections of the strakes 14, 15 give the hull good turning characteristics since the strakes together present a pair of faces giving rise to lateral forces on the hull for each sense of rotation of the hull, one face being provided by each strake. However, the hull does not provide excessive resistance to turning when the hull is not planing because of the triangular cross-section shape of the forward sections of the strakes 14, 15.

The rearward sections of the strakes 14, 15 can be made independently of the hull 11 and then be fixed to the hull 11. These sections may suffer from wear in use and thus can be made replaceable. They can also be made removable to allow removal of the removable panels 17 and 18.

It is preferable that the keel 16 is replaceable and takes the majority of wear during road use of the vehicle, as disclosed in the applicant's co-pending application no. GB0226443.0. The strakes 14 and 15 preferably do not extend lower than the keel 16 so that the keel preferentially receives ground impacts suffered by the hull in road use rather than the strakes 14, 15.

Whilst in the preferred embodiment described above two strakes 14, 15 are provided on the underside of hull 11, it will be appreciated that just one strake or indeed an array of strakes may be beneficially employed. Also, the location of strakes may be varied. Furthermore, whilst the section of the strakes in the preferred embodiment reduces from root to tip (i.e. the faces taper/converge to some degree), it is envisaged that alternative embodiments of hull according to the present invention could beneficially employ strakes whose section increases from root to tip (i.e. the faces diverge, of so-called 're-entrant' form). This may be achieved with integrally

moulded strakes or independent strakes which are assembled or are retrofit additions.

Where the hull is used on an amphibious vehicle, the strakes may be located inboard of wheel arches in the hull. The road wheels may be mounted on retractable suspensions as is known in the amphibious vehicle art, so that the wheels can be retracted on water to reduce hydrodynamic drag.